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The KL Mix Model Applied to Directly Driven Capsules on the Omega Laser

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The KL Mix Model Applied to Directly Driven Capsules on the Omega Laser*

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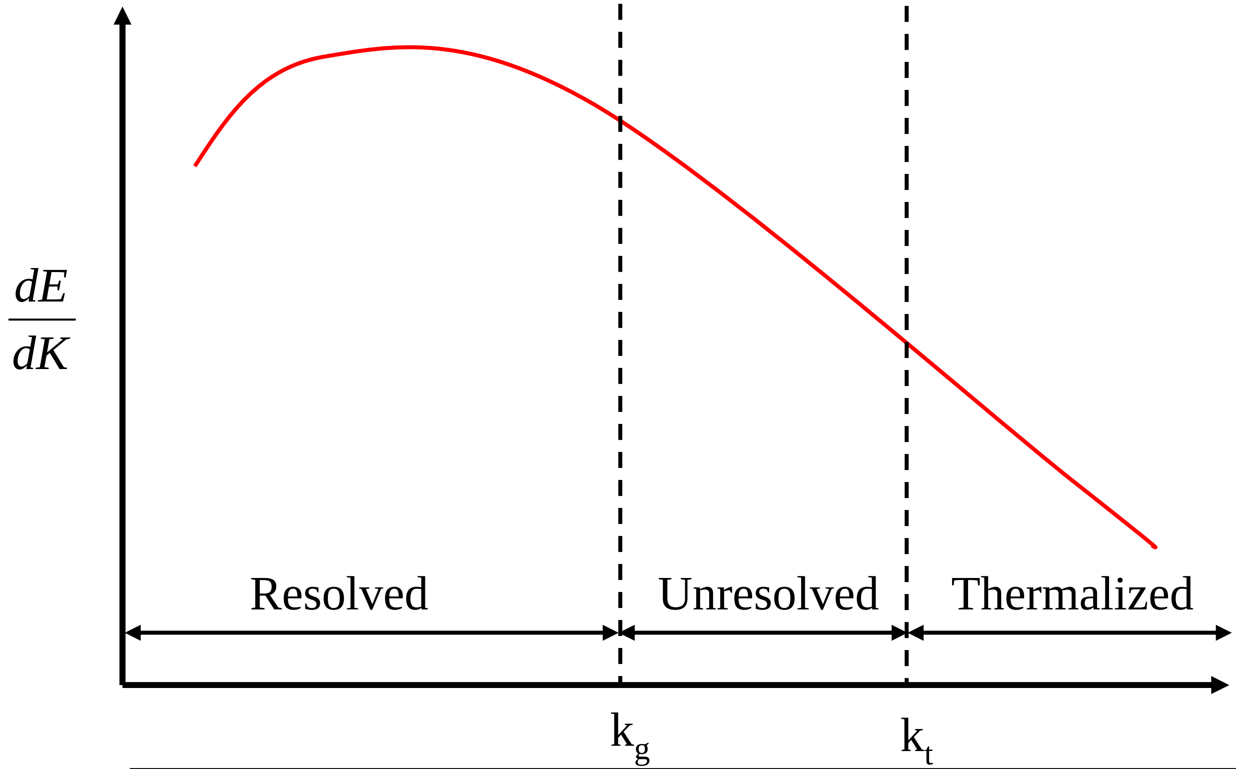
Main Points

- The coefficients of the KL mix model were set by Dimonte to match RT and RM instabilities as measured on the Linear Electric Motor (LEM).

- The KL mix model has been applied to directly-driven capsule implosions with a variety of laser energies, ablator materials, ablator thicknesses and convergence ratios.

- The KL calculations nearly match the observed Y_{DD}, Y_{DT}, Y_P, T_{ion} and implosion times for many (but not all) capsules.

The KL model characterizes sub-grid hydrodynamics with 2 variables



$$K = \int_{k_g}^{k_t} \frac{dE}{dk}\, dk$$

L is the characteristic eddy size

Please see Guy Dimonte's talk on the KL equations – **LO1.00009** 3:36 Wed Oct 26, 2005

All coefficients of the KL model can be derived from four numbers

- α_B = 0.07 – Young's RT bubble coefficient
- θ = 0.25 – RM exponent
- f_{PE} = 0.50 – Ratio of turbulent to potential energy
- C_c = 0. – the compression coefficient in the L eq.

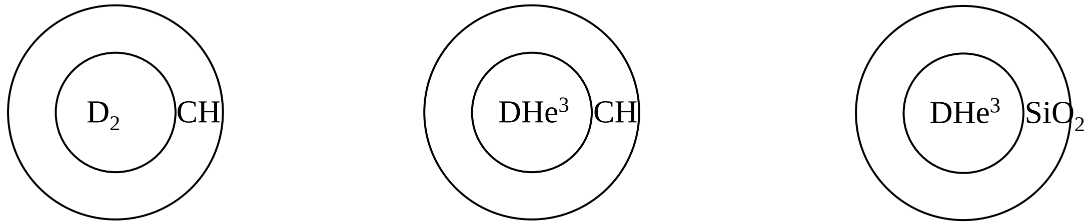
α_B inferred from LEM data is 0.06 rather than 0.07

The ideal value of C_c is 1/3 rather than 0

1D Calculations with CALEICF

- Sn radiation transport
- Electron thermal flux limiter of 0.05
- LTE opacities from SHM
- Lee-More thermal conductivities
- Thermonuclear reactions
- MC charged particle transport
- T+D => N + He4 reactions in flight
- He3+D => P + He4 reactions in flight
- Initialize L field to 50nm on inner surface
- Initialize L field to 50-150nm on outer surface

Three different types of capsules were tested



D_2 Fuel with CH Ablator

DHe^3 Fuel with CH Ablator

DHe^3 Fuel with SiO_2 Ablator

Three types of direct drive laser capsules were fired with different fuel pressures, ablator thickness and laser energies. Measured quantities include:

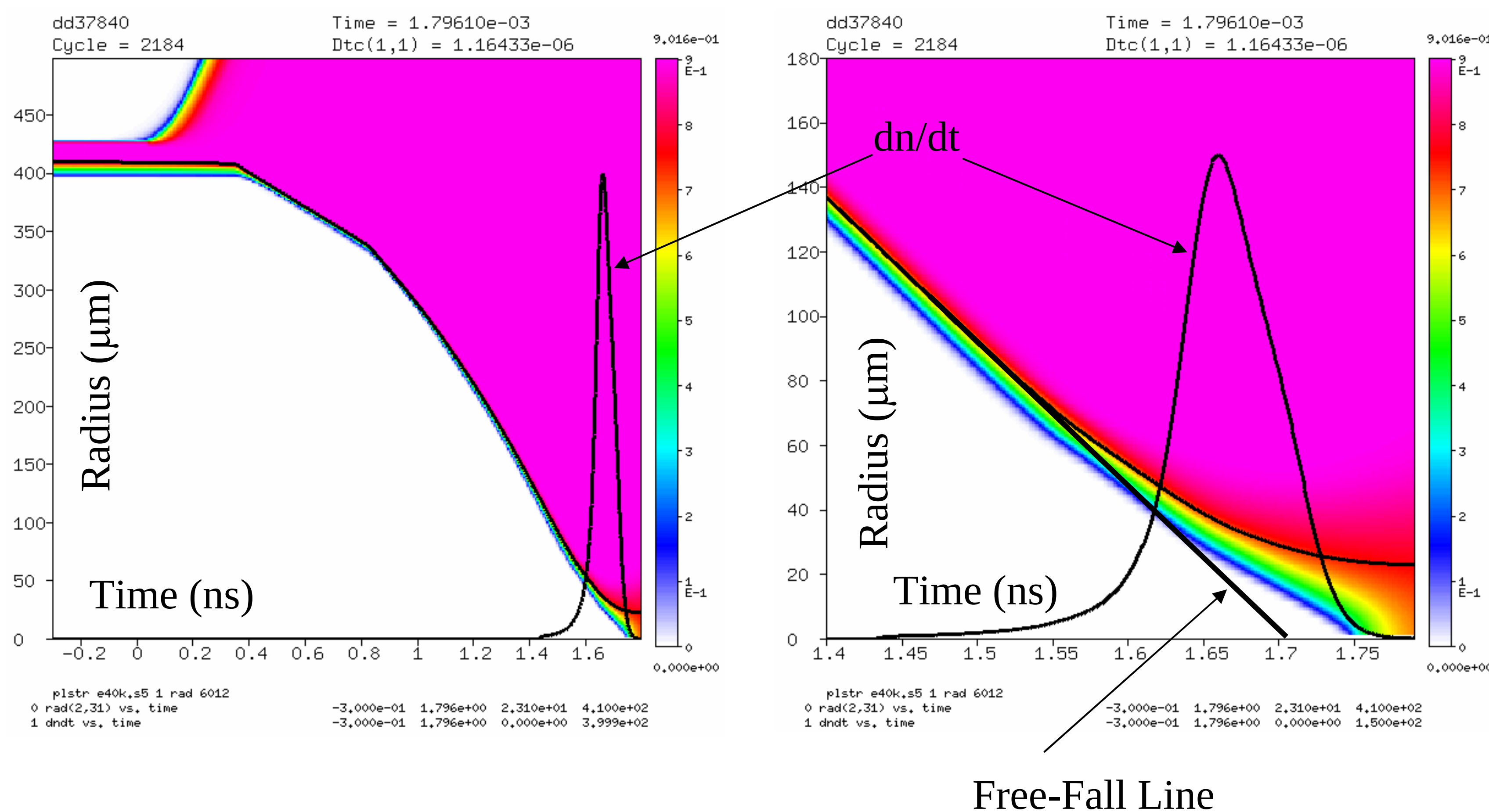
1 Primary DD neutrons and secondary DT neutrons

2 Primary DHe^3 protons (for D_2 fuels secondary DHe^3 protons were measured)

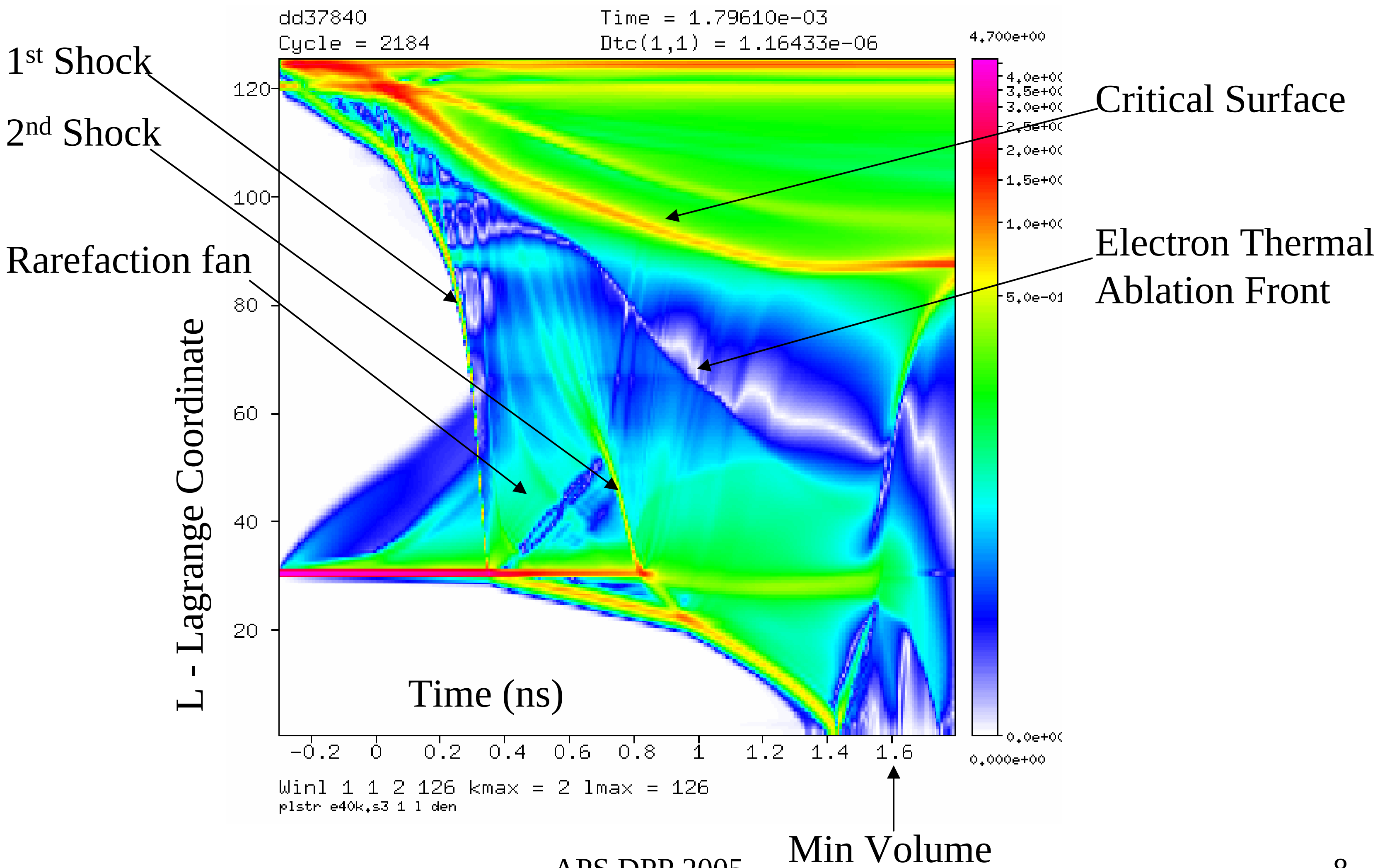
3 Ion temperatures (inferred from TOF spreading of the DD neutrons)

4 Implosion Time

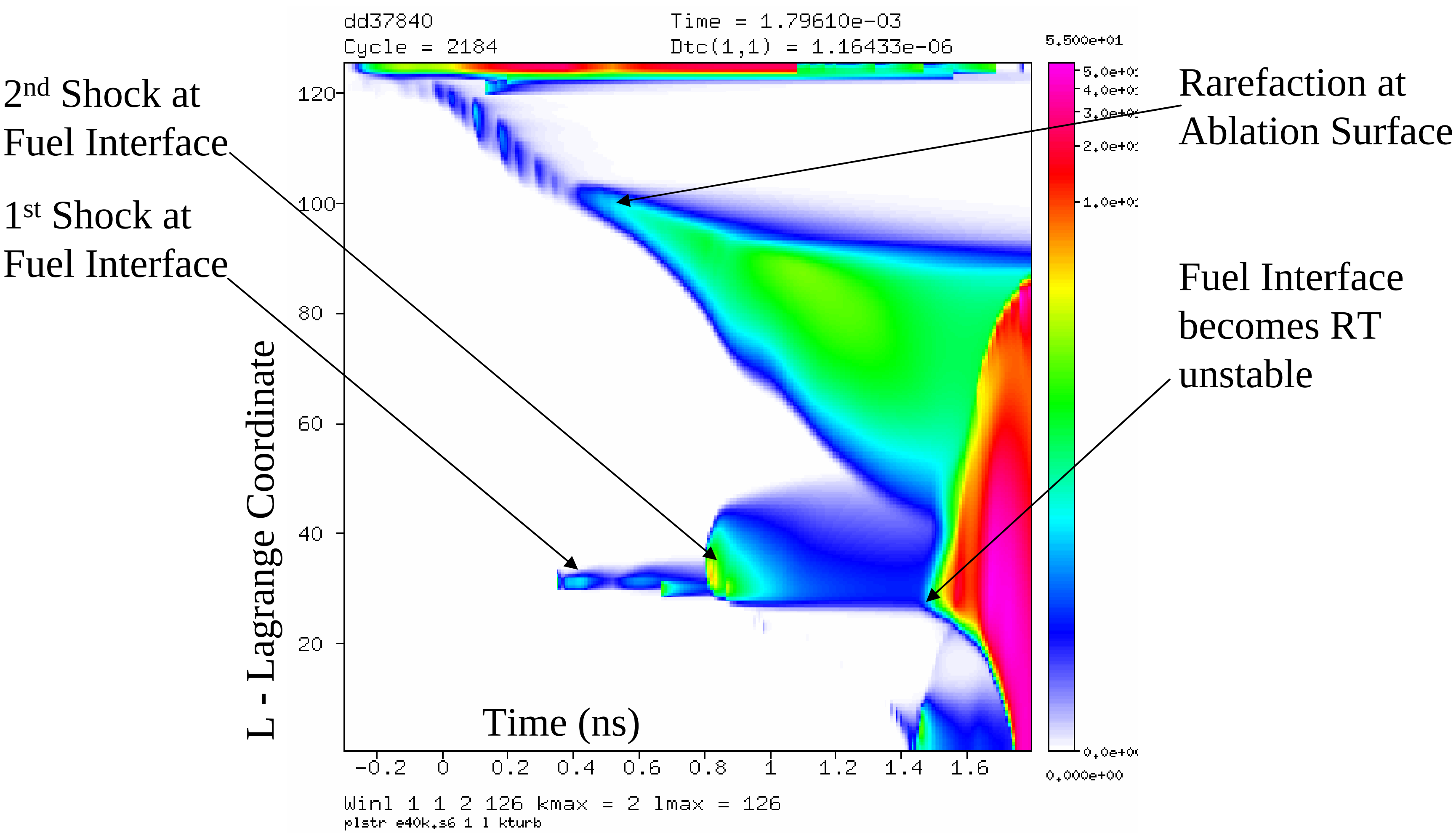
Carbon mass fraction front nearly follows the free-fall line



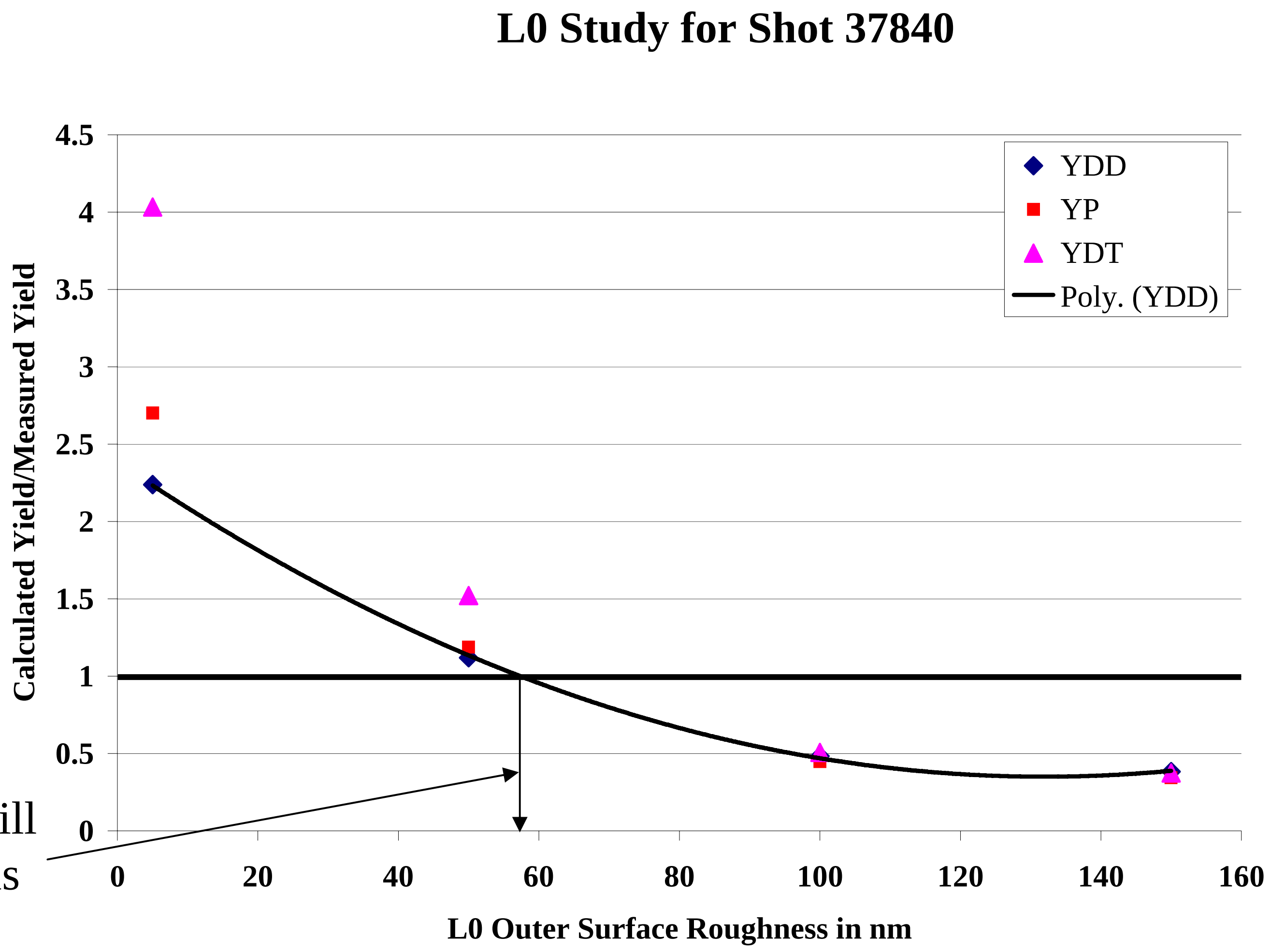
Streak plot of d log(ρ)/dL shows shocks, rarefactions and ablation fronts



Streak plot shows turbulent energy feeds through from thermal-ablation front to fuel surface

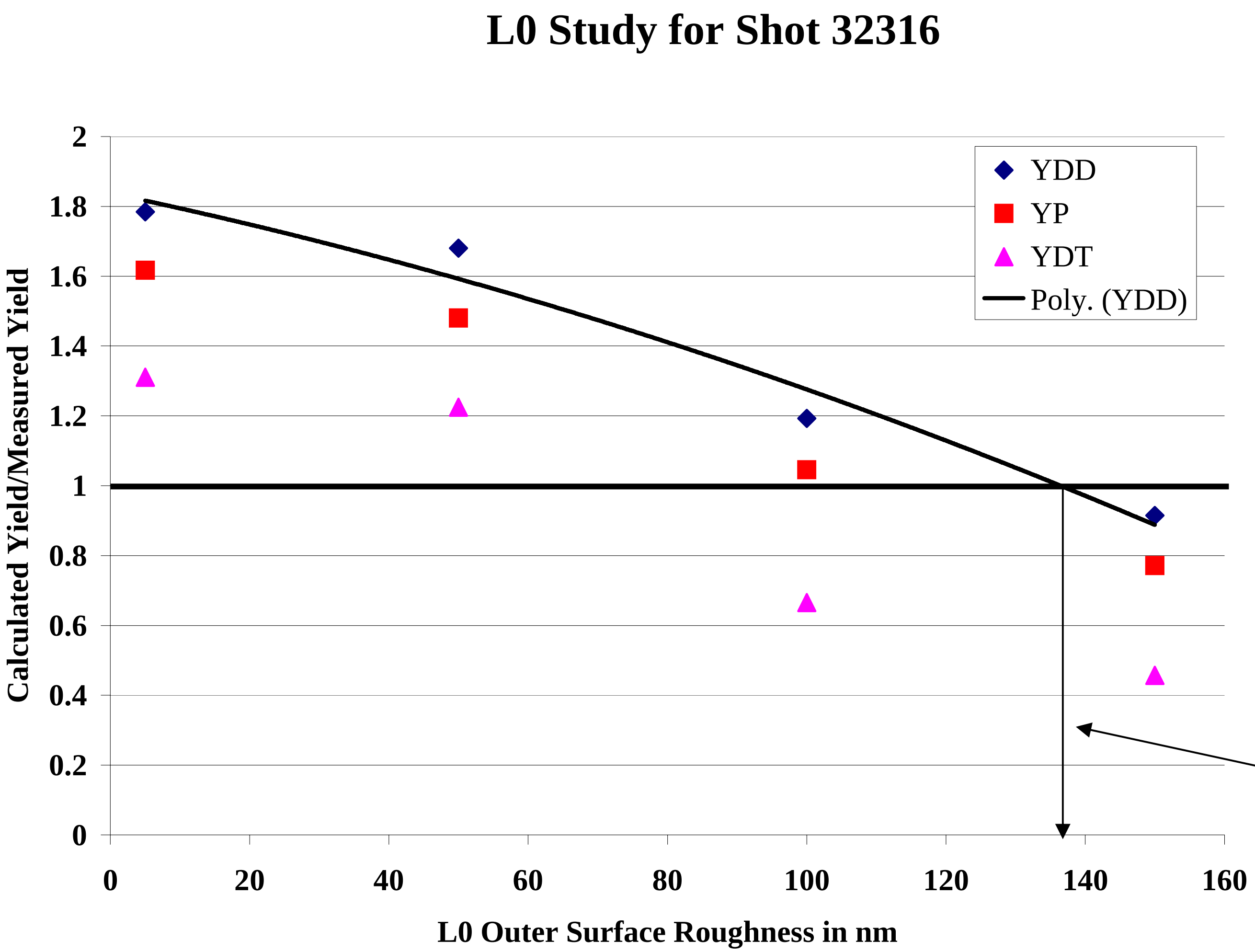


KL model predicts instabilities near laser absorption will degrade performance. Outer surface roughness can be adjusted to match data



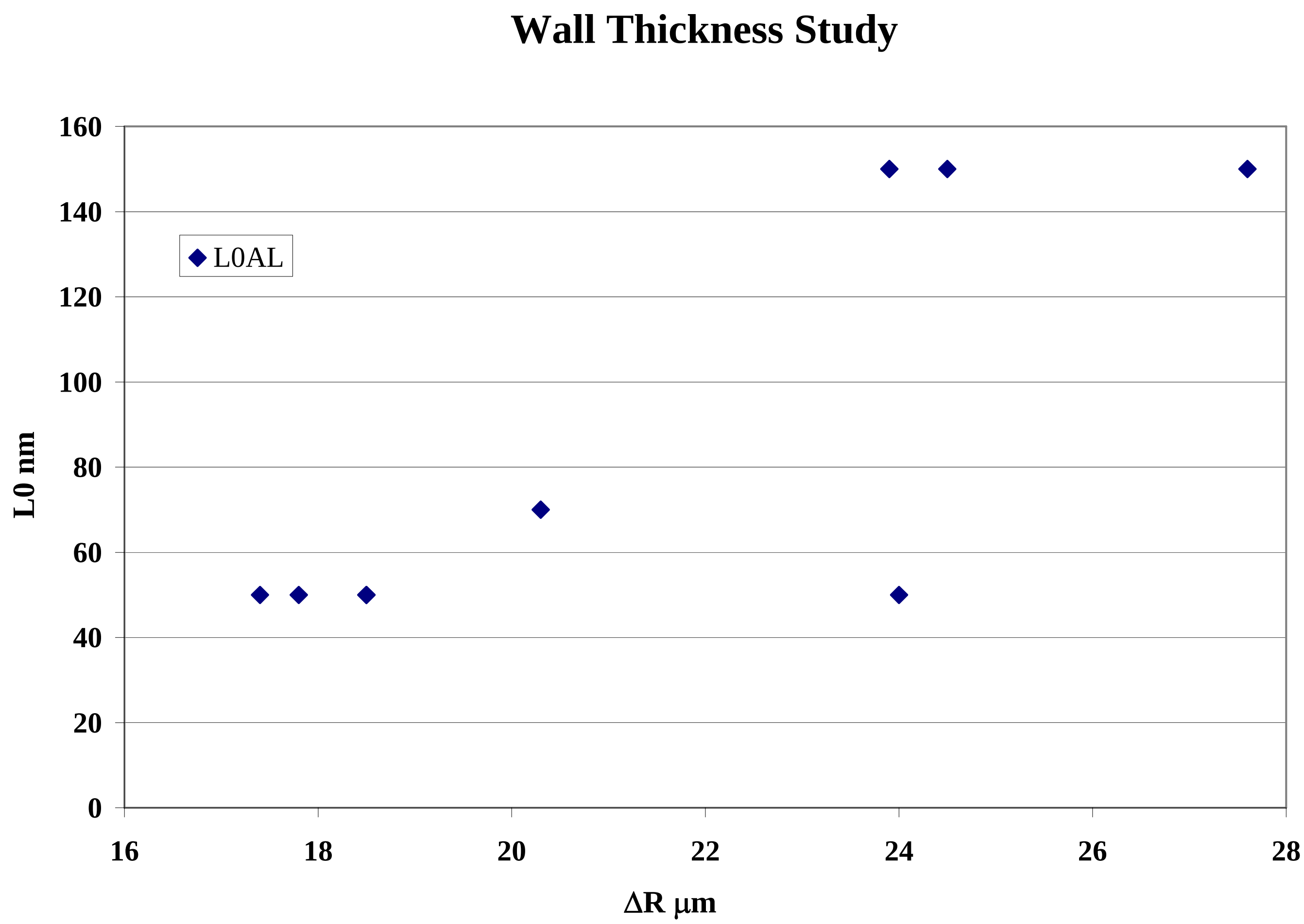
L_0 = 57nm on the outside surface will match data for this capsule

A surface roughness of 50-70nm gives good results for most capsules however, some require 150nm

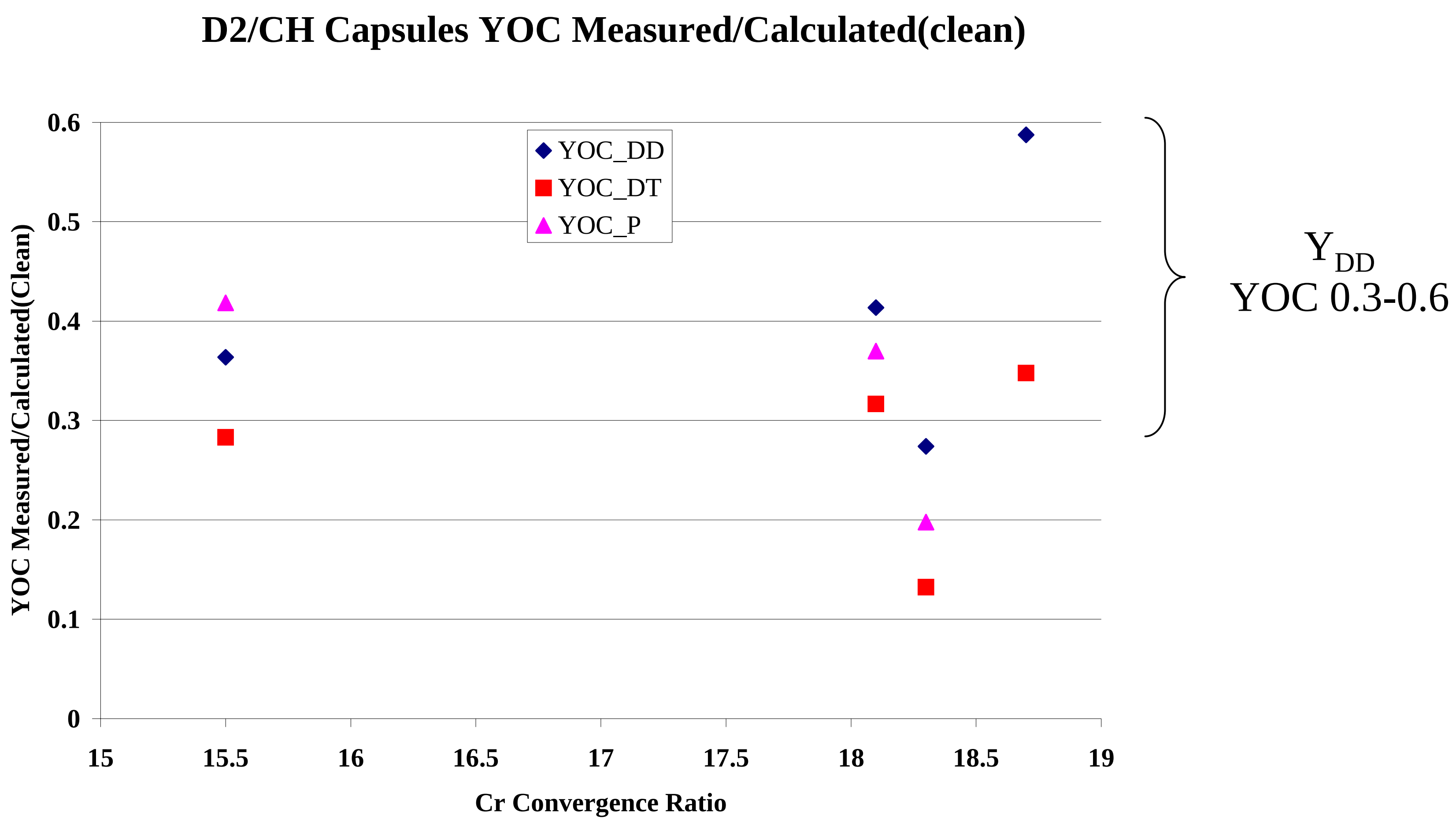


L_0 = 135nm on the outside surface will match data for this capsule

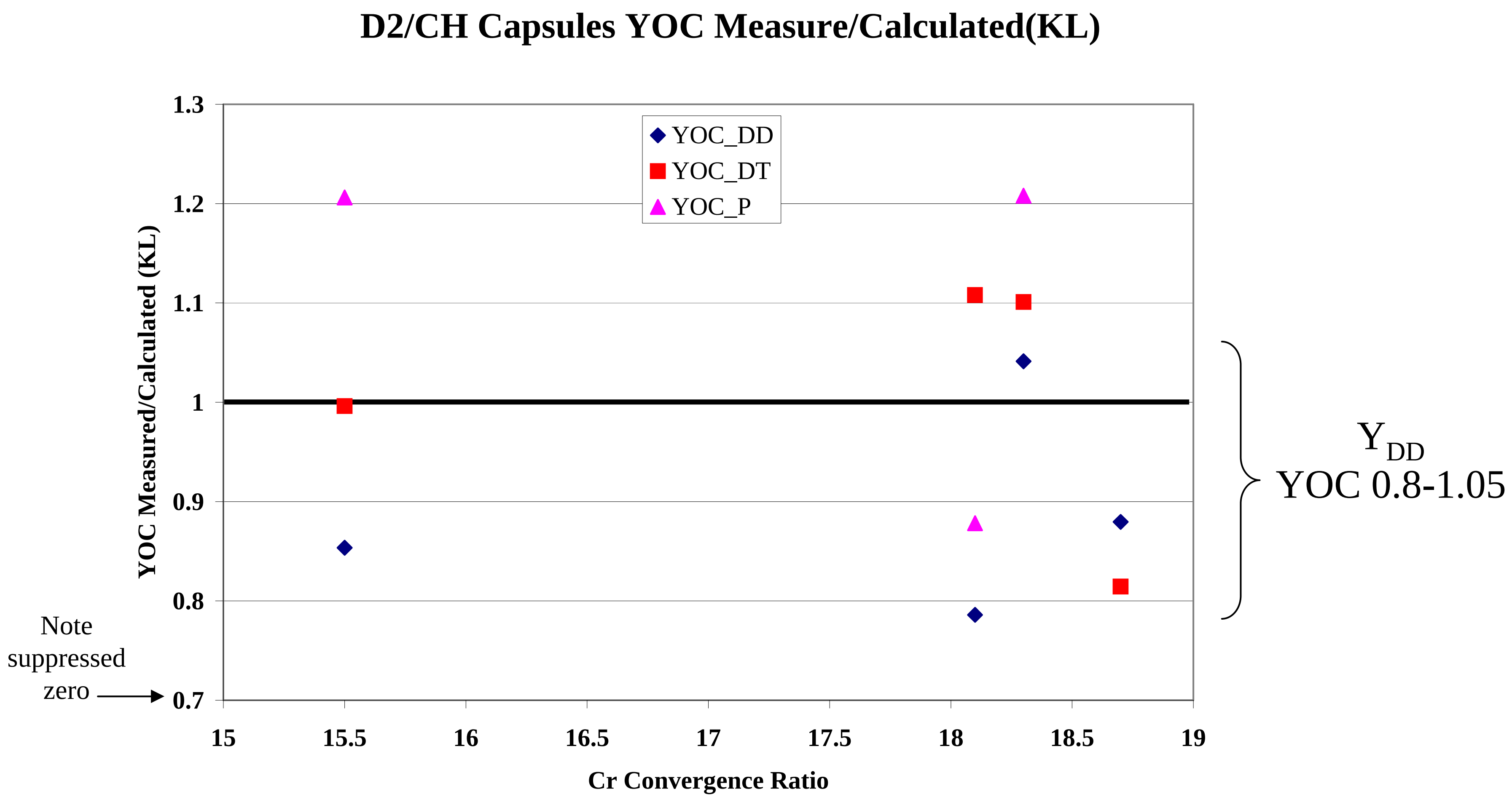
Thin capsules need L0 = 50 nm
Thick capsules need L0 = 150 nm



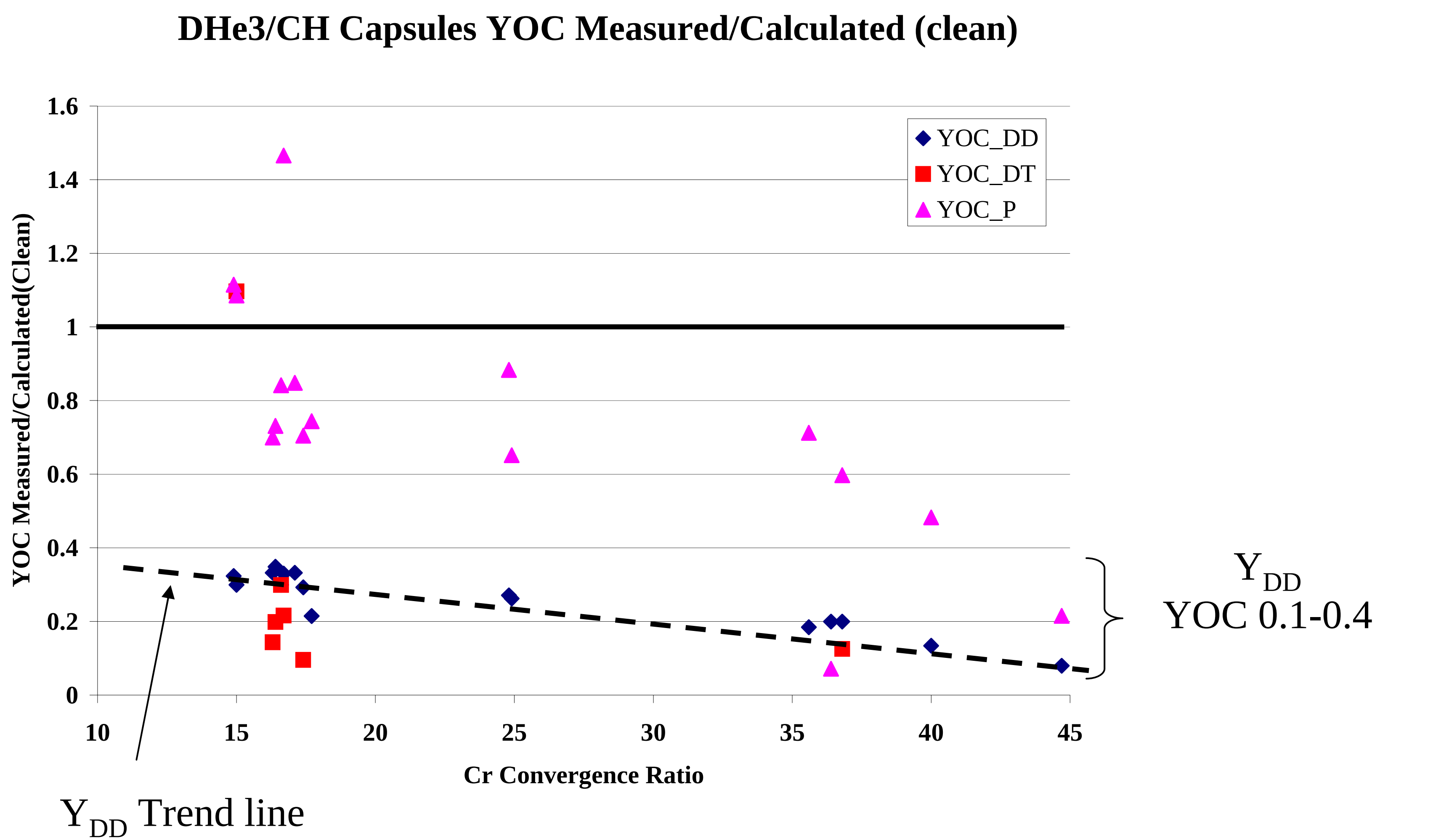
Y_{DD} from D_2/CH Capsules gave YOC(Clean) ~ 0.3-0.6



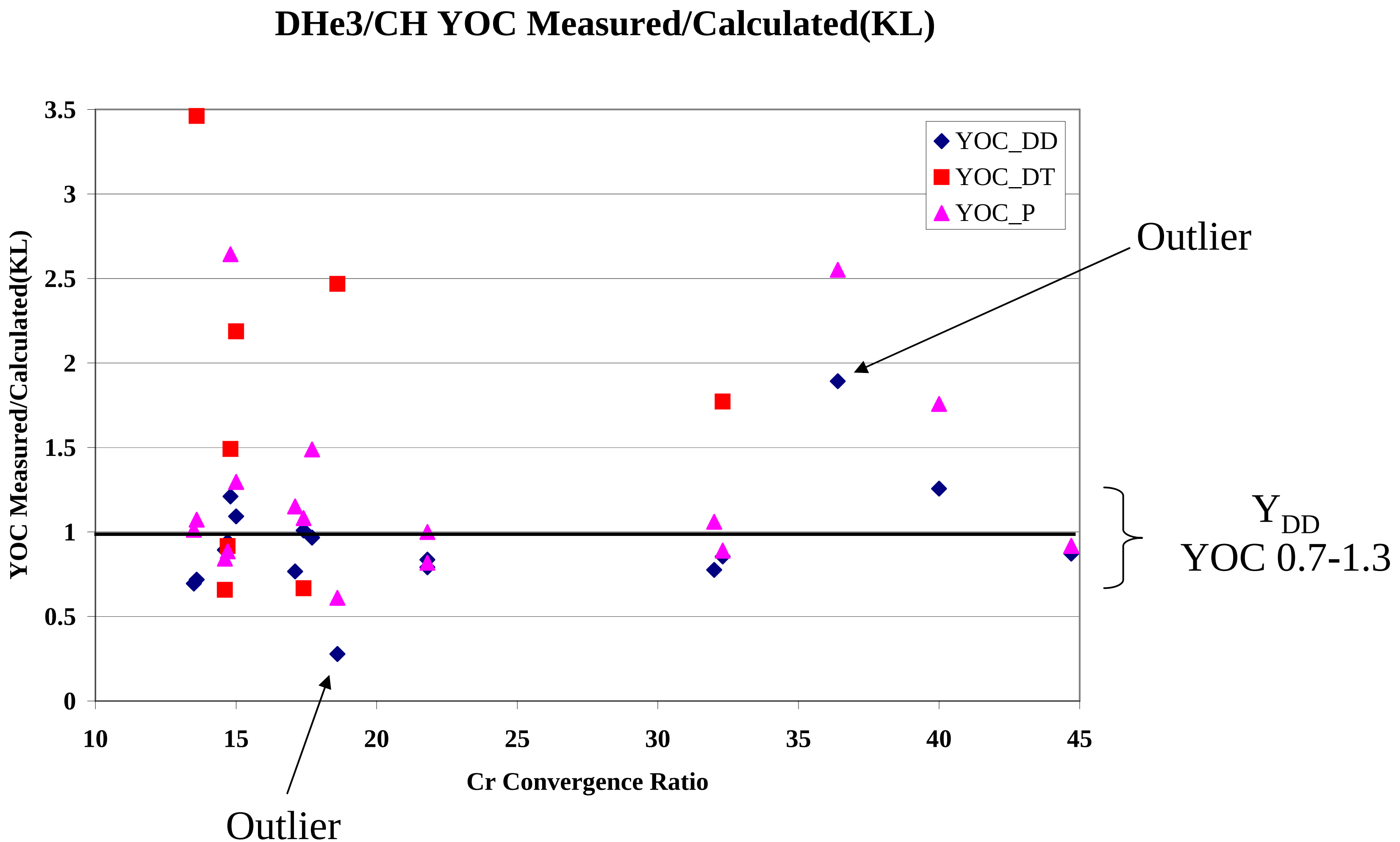
Y_{DD} from D_2/CH Capsules gives YOC(KL) ~ 0.8-1.05



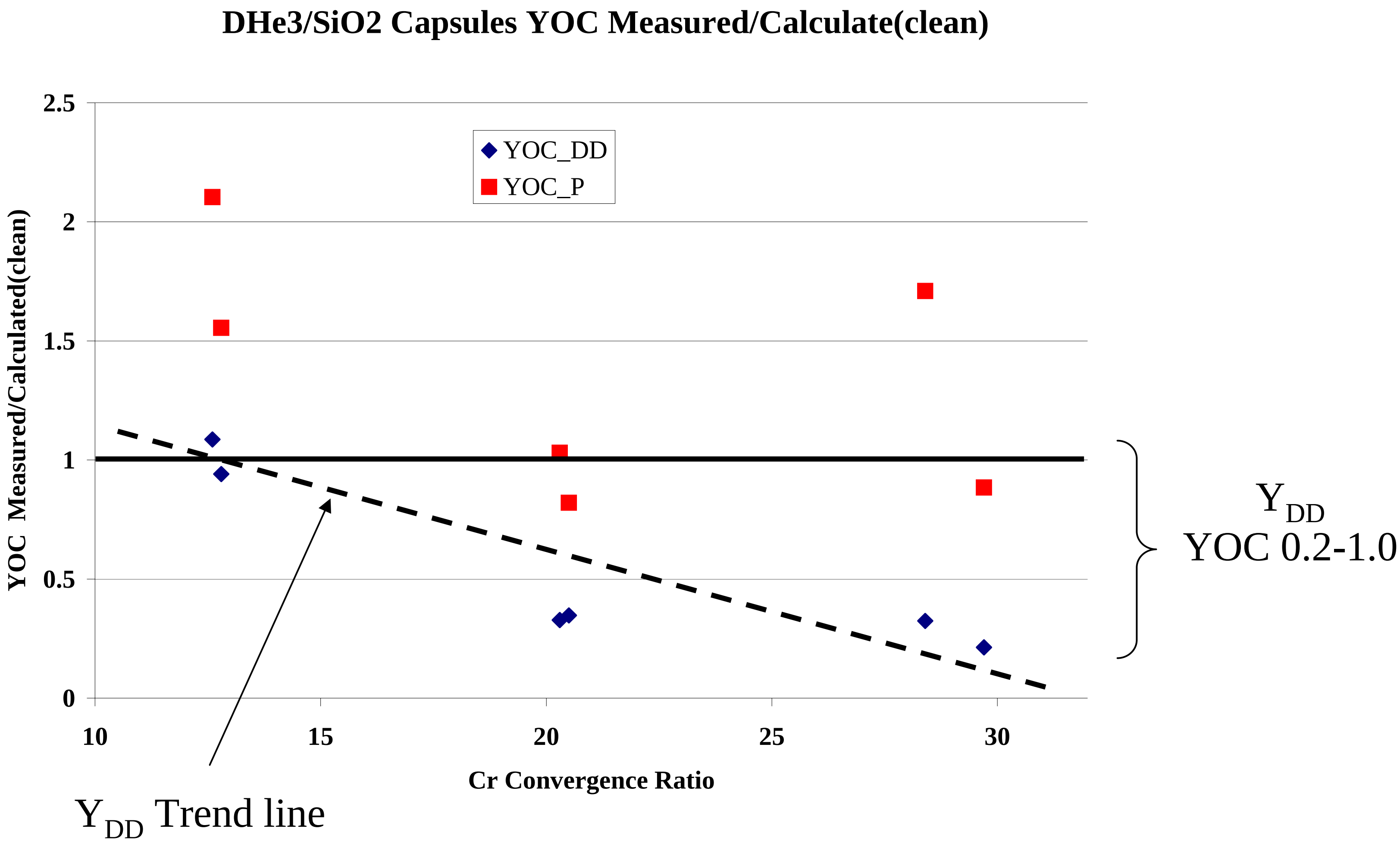
Y_{DD} from DHe^3/CH Capsules gave YOC(Clean) ~ 0.1-0.4



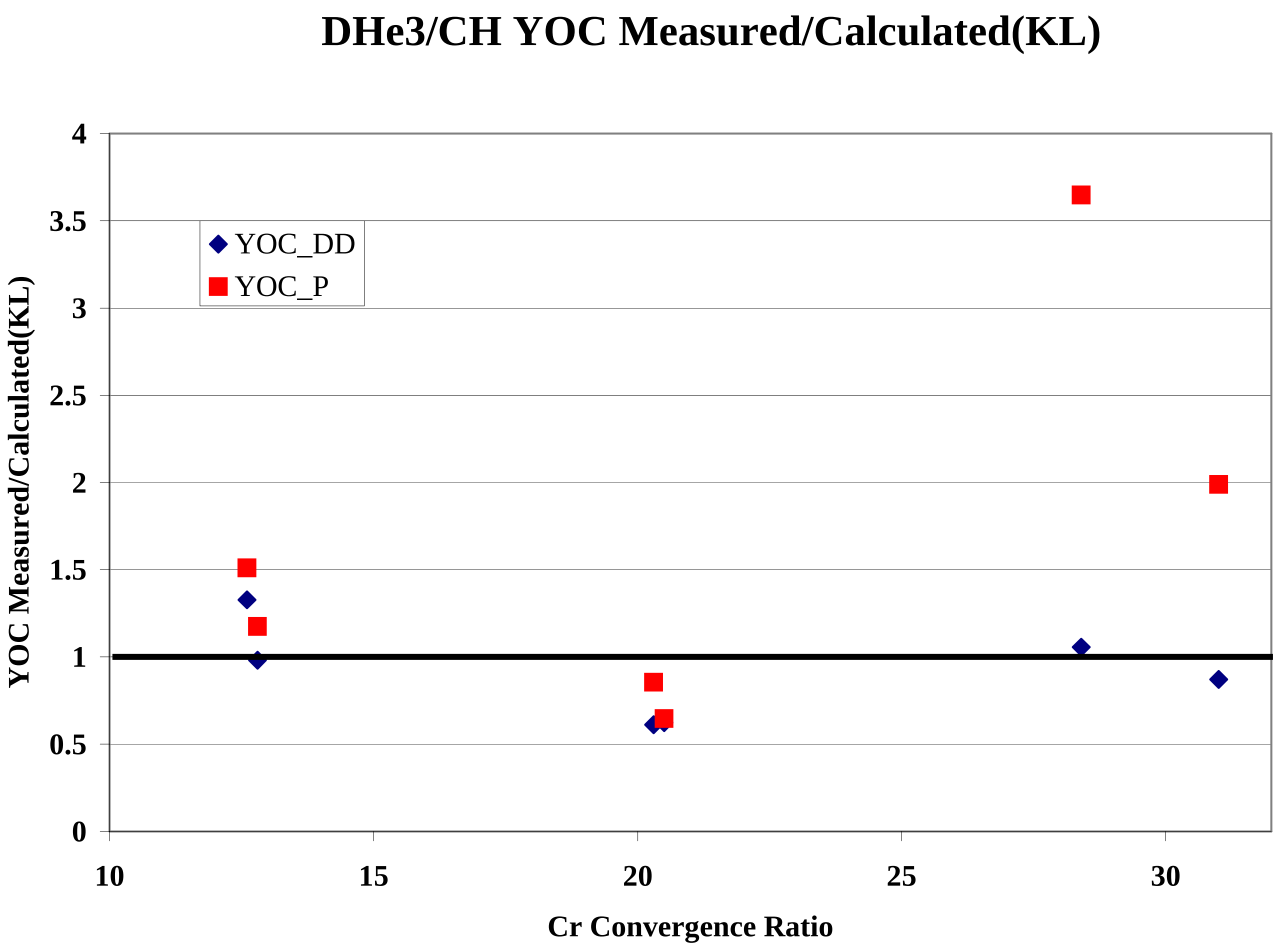
Y_{DD} from DHe^3/CH Capsules gives YOC(KL) ~ 0.7-1.3



Y_{DD} from DHe^3/SiO_2 Capsules gave YOC(Clean) ~ 0.2-1.0



Y_{DD} from DHe3/SiO_2 Capsules gave YOC(KL) ~ 0.6-1.3



Y_{DD}
YOC 0.6-1.3

Summary

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